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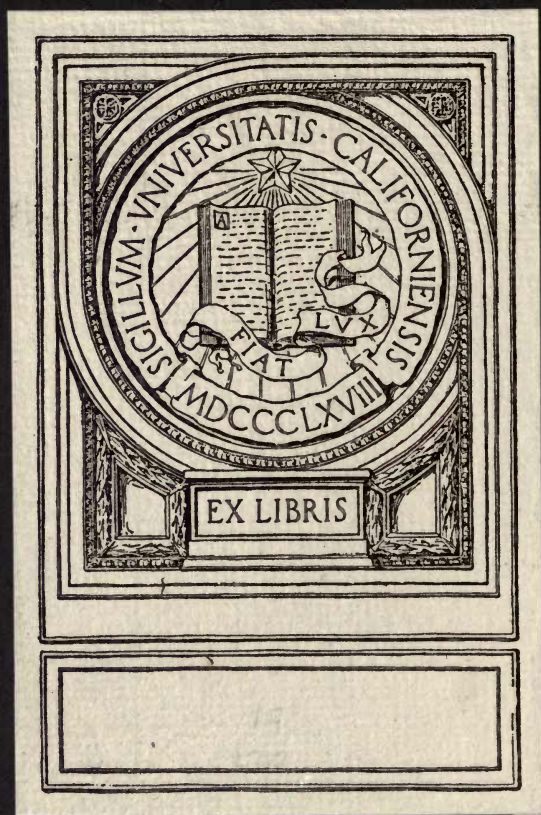
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American Society of Municipal Improvements, 1914

Specifications for Broken Stone and Gravel Roads

Adopted October 8, 1914

These specifications will be modified from time to time to keep them fully up to date. Suggestions as to modifications or additions are solicited and should be sent to the Secretary, or to A. H. Blanchard, Professor of Highway Engineering, Columbia University, New York City, Chairman of the Sub-Committee on Specifications for Broken Stone and Gravel Roads, and

GEORGE W. TILLSON

Boro Hall, Brooklyn, N. Y.

Chairman of General Committee on Standard Specifications

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SPECIFICATIONS FOR BROKEN STONE ROAD.

1. *General Description*.—The broken stone road shall consist of three courses of broken stone, separately constructed, laid to conform to the required grades and cross-sections and constructed as hereinafter specified.

BROKEN STONE.

2. *Quality of Broken Stone*.—All broken stone shall be clean, rough surfaced and sharp angled, of compact texture and uniform grain.

Tests for Broken Stone.—The broken stone shall be subjected to abrasion tests and toughness tests conducted by the Engineer in accordance with methods adopted by the American Society for Testing Materials, August 15, 1908. It shall show a "French coefficient of wear" of not less than 7.0 and its toughness shall be not less than 6.0.

3. *Sizes*.—The product of the crusher shall be passed over a rotary screen with sections having respectively circular openings of the following dimensions: First section, five-eighths ($\frac{5}{8}$) inch holes; second section, one and one-quarter ($1\frac{1}{4}$) inch holes; third section, two and one-quarter ($2\frac{1}{4}$) inch holes; fourth section, three and one-half ($3\frac{1}{2}$) inch holes. If so directed the first section of the screen shall be fitted with a dust jacket having one-quarter ($\frac{1}{4}$) inch openings so placed as to separate the dust from the product passing through the first section. The screening plant shall also be fitted with a tailing chute so that no stone failing to pass the largest openings will fall into the bin for No. 4 size broken stone. The various sizes of broken stone shall be caught in separate bins, and shall be designated as follows:

Dust, all passing through one-quarter ($\frac{1}{4}$)-inch screen.

Screenings, all passing through five-eighths ($\frac{5}{8}$) inch screen.

No. 1 size, passing through five-eighths ($\frac{5}{8}$) inch screen and over one-quarter ($\frac{1}{4}$) inch screen.

No. 2 size, passing over five-eighths ($\frac{5}{8}$) inch screen and through one and one-quarter ($1\frac{1}{4}$) inch screen.

No. 3 size, passing over one and one-quarter ($1\frac{1}{4}$) inch screen and through two and one-quarter ($2\frac{1}{4}$) inch screen.

No. 4 size, passing over two and one-quarter ($2\frac{1}{4}$) inch screen and through three and one-half ($3\frac{1}{2}$) inch screen.

Tailings, passing over three and one-half ($3\frac{1}{2}$) inch screen.

Portable Plants—Portable crushing and screening plants shall be operated as directed.

Stationary Plants—If broken stone is to be supplied from stationary crushing and screening plants, the several sizes of broken stone shall not be used unless samples have been previously approved by the Engineer. The various sizes of broken stone furnished shall be substantially the same as the samples approved.

CONSTRUCTION.

4. *First Course*—After the sub-grade or sub-base course shall have been prepared as specified, a course of No. 4 broken stone shall be evenly spread so that it shall have after rolling the required thickness of three and one-half ($3\frac{1}{2}$) inches. The depth of loose broken stone shall be gauged by the use of strings between iron stakes, as directed. The spreading of the broken stone must be from piles dumped on boards provided for the purpose or from piles dumped alongside the road, or as directed by the Engineer. This course shall be thoroughly rolled with a ten (10) to fifteen (15) ton road roller. The rolling shall begin at the sides of the road and continue towards the center and shall be kept up until there is no disturbance of the stone ahead of the roller. After the completion of the rolling, no teaming other than that necessary for bringing on the broken stone for the next course shall be allowed over the rolled broken stone. Should it be apparent

after the rolling of the first course that the subgrade material shall have become churned up into or mixed with the broken stone of this course, whether by reason of the rolling, or by hauling over the broken stone or otherwise, the Contractor shall at his own expense remove and replace such mixture of sub-grade material and broken stone with clean broken stone of the proper size and shall roll the material to produce a uniform, firm and even first course as required.

5. *Second Course*—On the completed first course shall be spread, in the manner specified in the preceding paragraph, No. 3 broken stone to form the second course. This broken stone shall be evenly spread to such a depth that it shall have after rolling the required thickness of two and one-half ($2\frac{1}{2}$) inches. After the second course shall be compacted under the same provisions as prescribed for the first course, it shall be evenly covered with a thin layer of screenings. The quantity of screenings to be used shall be just sufficient to cover the larger stones and care shall be exercised to avoid the use of an excess of the screenings. This covering shall then be rolled as heretofore provided. When the rolling shall have been completed the surface of the second course shall be firm, even and true to the lines, grades and cross-sections.

6. *Third Course*—On the completed second course shall be spread in the manner above specified for the first course No. 3 broken stone to form the third course. This broken stone shall be evenly spread to such a depth that it will have after rolling the required thickness of two and one-half ($2\frac{1}{2}$) inches. After the third course shall have been compacted under the same provisions as prescribed for the first course, it shall be evenly covered with a thin layer of screenings. The quantity of screenings to be used shall be just sufficient to cover the larger stones and care shall be exercised to avoid the use of an excess of the screenings. This covering shall then be rolled as heretofore provided except that water shall be used in connection with the rolling as follows: after the screenings shall have been lightly rolled, water shall be sprinkled on the road sur-

face just ahead of the roller in such quantity as will prevent the sticking to the wheels of the roller of the fine material on the surface, and the combined spreading of screenings, watering and rolling shall be continued until the voids of the broken stone become so filled with the finer particles as to result in a wave of grout being pushed along the road surface by the front wheel of the roller. When the rolling shall have been completed the surface of the third course shall be firm, even and true to the lines, grades and cross-sections. After the third course has been compacted, puddled and filled as above specified, it shall be evenly covered with a thin layer of screenings. Should at any time, after its construction and prior to the acceptance of the road, the larger stone be visible in the surface of the road, the Contractor shall, without extra allowance, spread, sprinkle and roll sufficient screenings to completely cover the same.

PAYMENT.

7. *Measurement and Payment*—The quantity of broken stone road to be paid for shall be the number of square yards, measured horizontally, satisfactorily completed in accordance with specifications. The price stipulated shall include the furnishing, crushing and screening of the different sizes of broken stone, the placing, rolling and watering of the broken stone, and all work and expenses incidental to the completion of the broken stone road.

SPECIFICATIONS FOR BROKEN STONE ROAD WITH BITUMINOUS SURFACE.

BROKEN STONE ROAD.

8. *General Description*—The broken stone road shall consist of three courses of broken stone, separately constructed, laid to conform to the required grades and cross-sections and constructed as hereinafter specified.

BROKEN STONE.

9. *Quality of Broken Stone*—All broken stone shall be clean, rough surfaced and sharp angled, of compact texture and uniform grain.

Tests For Broken Stone—The broken stone shall be subjected to abrasion tests and toughness tests conducted by the Engineer in accordance with methods adopted by the American Society for Testing Materials, August 15, 1908. The broken stone used for the construction of the first and second courses shall show a French coefficient of wear of not less than 7.0 and its toughness shall be not less than 6.0. The broken stone used for the construction of the third course and in connection with the bituminous surface shall show a French coefficient of wear of not less than 11.0 and its toughness shall not be less than 13.0.

10. *Sizes*—The sizes shall be in accordance with the requirements as stated in the paragraph entitled "Sizes" in the specifications for "Broken Stone Road."

CONSTRUCTION.

11. *First Course*—After the sub-grade or sub-base course shall have been prepared as specified, a course of No. 4 broken stone shall be evenly spread so that it shall have, after rolling, the required thickness of three and one-half ($3\frac{1}{2}$) inches. The depth of loose broken stone shall be gauged by the use of strings between iron stakes, as directed. The spreading of the broken stone must be from piles dumped on boards provided for the purpose or from piles dumped alongside the road, or as directed by the Engineer. This course shall be thoroughly rolled with a twelve (12) to fifteen (15) ton road roller. The initial rolling shall begin at the sides of the road and continue towards the center and shall be kept up until the stone is keyed together and there is no disturbance of the stone ahead of the roller. After the first course has been compacted, it shall be evenly covered with a thin layer of screenings. The quantity of screenings to be used shall be just suf-

ficient to cover the larger stones and care shall be exercised to avoid the use of an excess of the screenings. This covering shall then be rolled as heretofore provided except that water shall be used in connection with the rolling as follows: After the screenings shall have been lightly rolled, water shall be sprinkled on the road surface just ahead of the roller in such quantity as will prevent the sticking to the wheels of the roller of the fine material on the surface, and the combined spreading of screenings, watering and rolling shall be continued until the voids of the broken stone become so filled with the finer particles as to result in a wave of grout being pushed along the road surface by the front wheel of the roller. After the completion of the rolling, no teaming other than that necessary for bringing on the broken stone for the next course shall be allowed over the rolled broken stone. Should it be apparent after the rolling of the first course that the sub-grade material shall have become churned up into or mixed with the broken stone of this course, whether by reason of the rolling, or by hauling over the broken stone or otherwise, the Contractor shall at his own expense remove and replace such mixture of sub-grade material and broken stone with clean broken stone of the proper size and shall roll the material to produce a uniform, firm and even first course as required.

12. *Second Course*—On the completed first course shall be spread, in the manner specified in the preceding paragraph, No. 4 broken stone to form the second course. This broken stone shall be evenly spread to such a depth that it shall have, after rolling, the required thickness of three and one-half ($3\frac{1}{2}$) inches. The second course shall be compacted, puddled with screenings and water, and finished under the same provisions as prescribed for the first course. When the rolling shall have been completed, the surface of the second course shall be firm, even and true to the lines, grades and cross-sections. If the surface is not slightly rough, so as to afford a sufficient mechanical bond for the third course, it shall be broomed.

13. *Third Course*—On the completed second course shall be spread, in the manner above specified for the first course, No. 3 broken stone to form the third course. This broken stone shall be evenly spread to such a depth that it will have, after rolling, the required thickness of two and one-half ($2\frac{1}{2}$) inches. The third course shall be compacted and puddled with screenings and water under the same provisions as prescribed for the second course, and when the rolling shall have been completed, the surface of the third course shall be firm, even and true to the lines, grades and cross-sections. After the third course has been compacted, puddled and filled as above specified, it shall be evenly covered with a thin layer of screenings. Should at any time, after the construction of the third course and prior to the application of bituminous material thereon, the larger stone be visible in the surface of the road, the Contractor shall, without extra allowance, spread, sprinkle and roll sufficient screenings to completely cover the same. Each section of the broken stone road shall be subjected to traffic for at least one month before the construction of the bituminous surface thereon.

BITUMINOUS SURFACE.

14. *Description Bituminous Surface*—The bituminous surface shall consist of one application of refined tar covered with a layer of No. 1 broken stone constructed as hereinafter specified.

BITUMINOUS MATERIAL.

15. *Refined Tar*—Refined tar used in the construction of the bituminous surface shall conform with either one of the specifications covering the chemical and physical properties of refined tars included under the item entitled "Refined Tars for Surface Treatments."

16. *Heating Refined Tar*—The refined tar shall be heated in kettles or tanks so designed as to admit of even heating of the entire mass, with an efficient and positive control of the heat at all times. It shall be heated as directed by the

Engineer to a temperature between 93° C. (200° F.) and 121° C. (250° F.) All refined tar heated beyond 121° C. (250° F.) shall be rejected. No tar shall be heated in kettles or tanks containing any oil or asphalt cement. Before changing from one type to another, kettles or tanks shall be scrupulously cleaned in order to avoid mixtures of the two. Any mixtures of different kinds of bituminous materials shall be rejected.

Thermometers Furnished by Contractors—The Contractor shall provide a sufficient number of accurate, efficient, stationary thermometers for determining the temperature of the refined tar in kettles or tanks.

CONSTRUCTION.

17. *Preparation of Surface of Road*—Prior to the application of the refined tar, the surface of the broken stone road, when thoroughly dry, shall be swept clean of all dust, dirt or other loose material with horse or power drawn brooms and bass or other fine fibre brooms, or with stiff fibre hand brooms and bass or other fine fibre brooms, as directed by the Engineer. When the cleaning is completed the upper surface of the No. 3 broken stone shall be exposed, forming a clean mosaic surface.

18. *Application of Refined Tar*—After the surface shall have been cleaned to the satisfaction of the Engineer, and when thoroughly dry, the refined tar shall be uniformly applied over the prepared surface of the road by means of a pressure distributor as hereinafter specified and in accordance with the directions of the Engineer. The refined tar, when applied, shall have a temperature between 93° C. (200° F.) and 121° C. (250° F.). The total amount of refined tar to be used in the construction of the bituminous surface shall be applied in one application and shall not be less than one-quarter ($\frac{1}{4}$) nor more than one-half ($\frac{1}{2}$) gallon per square yard, the precise quantity being determined by the Engineer.

Pressure Distributor—The pressure distributor employed shall be so designed and operated as to distribute the refined

tar specified uniformly under a pressure of not less than twenty (20) pounds nor more than seventy-five (75) pounds per square inch in the amount and between the limits of temperature specified. It shall be supplied with an accurate stationary thermometer in the tank containing the refined tar and with an accurate pressure gauge so located as to be easily observed by the Engineer while walking beside the distributor. It shall be so operated that, at the termination of each run, the refined tar will be at once shut off. It shall be so designed that the normal width of application shall be not less than six (6) feet and so that it will be possible on either side of the machine to apply widths of not more than two (2) feet. The distributor shall be provided with tires of widths dependent upon the following relationship between the pressure per square inch of tire and the diameter of the wheel; for a two (2) foot diameter wheel, five hundred (500) pounds shall be the maximum pressure per linear inch of width per wheel, an additional pressure of thirty (30) pounds per inch being allowed for each additional three (3) inches in diameter.

19. *Application of No. 1 Broken Stone*—Immediately after the application of the refined tar, a layer of dry No. 1 broken stone, not to exceed three-eighths ($\frac{3}{8}$) of an inch in thickness, shall be spread and broomed as directed by the Engineer over the surface of the refined tar and shall be at once rolled as directed by the Engineer with a roller weighing between eight (8) and fifteen (15) tons.

20. *Seasonal and Weather Limitations*—No refined tar shall be applied when the air temperature in the shade is below 10° C. (50° F.), except by the written permission of the Engineer.

PAYMENT.

21. *Measurement and Payment*—The quantity of broken stone road with bituminous surface to be paid for under this item shall be the number of square yards, measured horizontally, satisfactorily completed in accordance with the specifications. The price stipulated in this item shall include the fur-

nishing, crushing and screening of the different sizes of broken stone, the placing, rolling and watering of the broken stone, the heating and distributing of the refined tar, and all materials, work and expenses incidental to the completion of the broken stone road with bituminous surface except the furnishing of the refined tar, which will be included for payment under the item entitled "Refined Tars for Surface Treatments."

SPECIFICATIONS FOR REFINED TAR FOR SURFACE TREATMENTS.

22. *Previous Service*—The Contractor will be required to show to the satisfaction of the Engineer, that the Company manufacturing the refined tar he proposes to use under a given specification has, for a period of at least two years, manufactured refined tar in a thoroughly equipped plant; and that refined tar manufactured of bituminous material obtained from a similar source to that which he proposes to use shall have been in continuous and successful use in the surface treatment of broken stone roads for a period of at least two years previous to the date of the letting in which his proposal was submitted.

23. *Refined Tar "A" Optional With Refined Tar "B."*

(I) Refined tar "A" shall be homogeneous, free from water and shall not foam when heated to 121° C. (250° F.)

(II) Its specific gravity at a temperature of 25° C. (77° F.) shall be not less than 1.140 nor more than 1.180.

(III) When tested by means of the New York Testing Laboratory Float Apparatus, the float shall not sink in water maintained at 50° C. (122° F.) in less than 50 seconds nor more than 110 seconds.

(IV) Its bitumen as determined by its solubility in chemically pure carbon disulphide at room temperature, shall be not less than 95.0 per cent. and it shall show not more than 0.2 per cent. ash upon ignition of the material insoluble in carbon disulphide.

(V) When distilled according to the tentative method recommended by Committee D-4 of the American Society for Testing Materials in 1911, it shall yield no distillate at a temperature lower than 170° C. (338° F.); not more than 20.0 per cent. shall distill below 270° C. (518° F.), and not more than 30.0 per cent. shall distill below 300° C. (572° F.).

(VI) The melting point as determined in water by the cube method, of the pitch residue remaining after distillation to 300° C. (572° F.) in accordance with the test described in Clause (V) shall be not more than 75° C. (167° F.).

24. *Refined Tar "B" Optional With Refined Tar "A."*

(I) Refined tar "B" shall be homogeneous, free from water, and shall not foam when heated to 121° C. (250° F.).

(II) Its specific gravity at a temperature of 25° C. (77° F.) shall be not less than 1.170 nor more than 1.220.

(III) When tested by means of the New York Testing Laboratory Float Apparatus, the float shall not sink in water maintained at 50° C. (122° F.) in less than 40 seconds nor more than 100 seconds.

(IV) Its bitumen as determined by its solubility in chemically pure carbon disulphide at room temperature, shall be not less than 85.0 per cent. nor more than 95.0 per cent., and it shall show not more than 0.2 per cent ash upon ignition of the material insoluble in carbon disulphide.

(V) When distilled according to the tentative method recommended by Committee D-4 of the American Society for Testing Materials in 1911, it shall yield no distillate at a temperature lower than 170° C. (338° F.); not more than 20.0 per cent. shall distill below 270° C. (518° F.), and not more than 25.0 per cent. shall distill below 300° C. (572° F.).

(VI) The melting point as determined in water by the cube method, of the pitch residue remaining after distillation to 300° C. (572° F.) in accordance with the test described in Clause (V) shall be not more than 75° C. (167° F.).

25. *Delivery*—The refined tar shall be delivered in suitable containers, far enough in advance of its use in the work to

permit the necessary tests to be made. Each container shall be plainly labeled with the trade name of the refined tar, name of manufacturer, gross weight and net weight. Each shipment and each carload shall be kept separate.

Bills of Lading—The Contractor shall furnish the Engineer on or before the arrival of each shipment at or near the site of the work, bills of lading, or correct copies thereof, which shall state the trade name of the refined tar, and the name and address of the Company manufacturing and supplying it.

Samples—Samples will be taken by the Engineer from each carload of refined tar when delivered at the work, unless satisfactory arrangements can be made for sampling before shipment. Such samples shall be analyzed by the Engineer to assure the delivery of a refined tar of the specified quality and to determine, for purpose of payment, the quantity of bitumen.

26. *Work Included*—Under this item the Contractor shall furnish and deliver on the work at such points as directed refined tar which conforms with the specifications of either refined tar "A" or refined tar "B."

27. *Measurement and Payment*—The quantity of bitumen in the refined tar, to be paid for under this item, shall be the number of tons, determined in accordance with the paragraph headed "Samples" contained in the refined tar placed on the road in accordance with the specifications and requirements, or used as directed for other purposes. The percentage of bitumen determined by an average of the analyses of the acceptable samples taken by the Engineer during a given month shall be used as the basis for payment for the refined tar used during that month. Refined tar that is wasted shall not be included in the measurement under this item. The price stipulated in this item shall include the cost of furnishing, hauling and delivering the refined tar at the work, and all expenses incidental thereto.

SPECIFICATIONS FOR BITUMINOUS MACADAM PAVEMENT.

28. *General Description*—The bituminous macadam pavement shall consist of three courses of broken stone, separately constructed, laid to conform to the required grades and cross-sections, and constructed as hereinafter specified with bituminous material incorporated with the top or third course.

BROKEN STONE.

29. *Quality of Broken Stone*—All broken stone shall be clean, rough surfaced and sharp angled, of compact texture and uniform grain.

Tests For Broken Stone—The broken stone shall be subjected to abrasion tests and toughness tests conducted by the Engineer in accordance with methods adopted by the American Society for Testing Materials, August 15, 1908. The broken stone used for the construction of the first and second courses shall show a French coefficient of wear of not less than 7.0 and its toughness shall be not less than 6.0. The broken stone used for the construction of the third course and for the first and second applications of No. 1 broken stone shall show a French coefficient of wear of not less than 11.0 and its toughness shall not be less than 13.0.

30. *Sizes*—The sizes shall be in accordance with requirements as stated in the paragraph entitled "Sizes" in the specifications for "Broken Stone Road."

CONSTRUCTION.

31. *First Course*—After the sub-grade or sub-base course shall have been prepared as specified, a course of No. 4 broken stone shall be evenly spread so that it shall have, after rolling, the required thickness of three and one-half ($3\frac{1}{2}$) inches. The depth of loose broken stone shall be gauged by the use of strings between iron stakes, as directed. The spreading of the broken stone must be from piles dumped on boards provided for the purpose or from piles dumped alongside the road, or as directed by the Engineer. This course shall be

thoroughly rolled with a twelve (12) to fifteen (15) ton road roller. The initial rolling shall begin at the sides of the road and continue towards the center and shall be kept up until the stone is keyed together and there is no disturbance of the stone ahead of the roller. After the first course has been compacted, it shall be evenly covered with a thin layer of screenings. The quantity of screenings to be used shall be just sufficient to cover the larger stones and care shall be exercised to avoid the use of an excess of the screenings. This covering shall then be rolled as heretofore provided except that water shall be used in connection with the rolling as follows: After the screenings shall have been lightly rolled, water shall be sprinkled on the road surface just ahead of the roller, in such quantity as will prevent the sticking to the wheels of the roller of the fine material on the surface, and the combined spreading of screenings, watering and rolling shall be continued until the voids of the broken stone become so filled with the finer particles as to result in a wave of grout being pushed along the road surface by the front wheel of the roller. After the completion of the rolling, no teaming other than that necessary for bringing on the broken stone for the next course shall be allowed over the rolled broken stone. Should it be apparent after the rolling of the first course that the sub-grade material shall have become churned up into or mixed with the broken stone of this course, whether by reason of the rolling, or by hauling over the broken stone or otherwise, the Contractor shall at his own expense remove and replace such mixture of sub-grade material and broken stone with clean broken stone of the proper size and shall roll the material to produce a uniform, firm and even first course as required.

32. *Second Course*—On the completed first course shall be spread, in the manner specified in the preceding paragraph, No. 4 broken stone to form the second course. This broken stone shall be evenly spread to such a depth that it shall have, after rolling, the required thickness of three and one-half

(31½) inches. The second course shall be compacted, puddled with screenings and water, and finished under the same provisions as prescribed for the first course. When the rolling shall have been completed, the surface of the second course shall be firm, even and true to the lines, grades and cross-sections. If the surface is not slightly rough so as to afford a sufficient mechanical bond for the third course, it shall be broomed.

TOP COURSE, BITUMINOUS MACADAM PAVEMENT.

33. *Description of Top Course*—The top course of the bituminous macadam pavement shall consist of a third course of broken stone and two applications of bituminous material, each application being followed by the distribution of a layer of No. 1 broken stone, constructed as hereinafter specified.

BITUMINOUS MATERIAL.

34. *Asphalt Cement and Refined Tar*—The asphalt cement or refined tar, hereinafter referred to as bituminous material, used in the construction of the third course of the bituminous macadam pavement shall conform with either one of the specifications covering the chemical and physical properties of bituminous materials included under the item entitled "Asphalt Cements and Refined Tars for Bituminous Macadam Pavement."

35. *Heating Bituminous Materials*—Bituminous materials shall be heated in kettles or tanks so designed as to admit of even heating of the entire mass, with an efficient and positive control of the heat at all times. Asphalt cement shall be heated as directed by the Engineer to a temperature between 135° C. (275° F.) and 177° C. (350° F.) All asphalt cement heated beyond 177° C. (350° F.) shall be rejected. Refined tar shall be heated as directed by the Engineer to a temperature between 93° C. (200° F.) and 121° C. (250° F.). All refined tar heated beyond 121° C. (250° F.) shall be rejected. No tar shall be heated in kettles or tanks containing any oil or asphalt cement. Before changing from one type of ma-

terial to another, kettles or tanks shall be scrupulously cleaned in order to avoid mixtures of the two. Any mixtures of different kinds of bituminous materials shall be rejected.

Thermometers Furnished by Contractors—The Contractor shall provide a sufficient number of accurate, efficient, stationary thermometers for determining the temperature of the bituminous material in kettles or tanks.

CONSTRUCTION.

36. *Third Course of Broken Stone*—On the completed second course, when thoroughly dry, shall be spread, in the manner above specified for the first course, dry No. 3 broken stone to form the third course. This broken stone shall be evenly spread to such a depth that it will have, after rolling, the required thickness of two and one-half ($2\frac{1}{2}$) inches. The third course shall be thoroughly compacted by dry rolling until the fragments of broken stone have just keyed together in accordance with the same provisions covering rolling as prescribed for the "First Course."

37. *First Application of Bituminous Material*—After the third course of broken stone shall have been thoroughly compacted as specified and when clean and thoroughly dry, the bituminous material shall be uniformly applied over the prepared surface of the third course by means of a pressure distributor as hereinafter specified. The asphalt cement, when applied, shall have a temperature between 135° C. (275° F.) and 177° C. (350° F.). The refined tar, when applied, shall have a temperature between 93° C. (200° F.) and 121° C. (250° F.). The total amount of bituminous material to be used in the first application shall not be less than one and one-half ($1\frac{1}{2}$) gallons nor more than one and three-quarters ($1\frac{3}{4}$) gallons per square yard, the precise quantity being determined by the Engineer.

Pressure Distributor—The pressure distributor employed shall be so designated and operated as to distribute the bituminous materials specified uniformly under a pressure of

not less than twenty (20) pounds nor more than seventy-five (75) pounds per square inch in the amount and between the limits of temperature specified. It shall be supplied with an accurate stationary thermometer in the tank containing the bituminous material and with an accurate pressure gauge so located as to be easily observed by the Engineer while walking beside the distributor. It shall be so operated that, at the termination of each run, the bituminous material will be at once shut off. It shall be so designed that the normal width of application shall be not less than six (6) feet and so that it will be possible on either side of the machine to apply widths of not more than two (2) feet. The distributor shall be provided with wheels having tires each of which shall not be less than eighteen (18) inches in width, the allowed maximum pressure per square inch of tire being dependent upon the following relationship between the aforesaid pressure and the diameter of the wheel: For a two (2) foot diameter wheel, two hundred and fifty (250) pounds shall be the maximum pressure per linear inch of width of tire per wheel, an additional pressure of twenty (20) pounds per inch being allowed for each additional three (3) inches in diameter.

38. *First Application of No. 1 Broken Stone*—Immediately after the application of the bituminous material, a layer of dry No. 1 broken stone, not to exceed three-eighths ($\frac{3}{8}$) of an inch in thickness, shall be spread as directed by the Engineer over the surface of the bituminous material and shall be at once rolled as directed by the Engineer with a roller weighing between twelve (12) and fifteen (15) tons. During the rolling process, additional No. 1 broken stone shall be applied and broomed until the voids in the upper portion of the third course are filled to the satisfaction of the Engineer.

39. *Second Application of Bituminous Material*—Prior to the second application of bituminous material, all loose No. 1 broken stone shall be swept from the surface of the pavement. When thoroughly clean and dry, a second application of bituminous material shall be uniformly applied over the surface

by means of a pressure distributor as specified above. When applied the asphalt cement shall have a temperature between 135° C. (275° F.) and 177° C. (350° F.). When applied the refined tar shall have a temperature between 93° C. (200° F.) and 121° C. (250° F.). The total amount of bituminous material to be used in the second application shall not be less than one-half ($\frac{1}{2}$) gallon nor more than three-quarters ($\frac{3}{4}$) gallon per square yard, the precise quantity being determined by the Engineer.

40. *Second Application of No. 1 Broken Stone*—Immediately after the second application of bituminous material, a layer of dry No. 1 broken stone, not to exceed three-eighths ($\frac{3}{8}$) of an inch in thickness, shall be spread and broomed as directed by the Engineer over the surface of the bituminous material and thereafter at once rolled as directed by the Engineer with a roller weighing between twelve (12) and fifteen (15) tons. The rolling shall be continued and additional No. 1 broken stone shall be applied until a smooth, uniform surface is produced to the satisfaction of the Engineer.

41. *Seasonal and Weather Limitations*—No bituminous material shall be applied when the air temperature in the shade is below 10° C. (50° F.), except by the written permission of the Engineer.

PAYMENT.

42. *Measurement and Payment*—The quantity of bituminous macadam pavement to be paid for under this item shall be the number of square yards, measured horizontally, satisfactorily completed in accordance with the specifications. The price stipulated in this item shall include the furnishing, crushing and screening of the different sizes of broken stone, the heating and distributing of the bituminous material, and all materials, work and expenses incidental to the completion of the bituminous macadam pavement except the furnishing of the bituminous material, which will be included for payment under the item entitled "Asphalt Cements and Refined Tars for Bituminous Macadam Pavements."

SPECIFICATIONS FOR ASPHALT CEMENTS AND REFINED
TARS FOR BITUMINOUS MACADAM PAVEMENTS.

43. *Previous Service*—The Contractor will be required to show, to the satisfaction of the Engineer, that the Company manufacturing the asphalt cement or refined tar he proposes to use under a given specification has, for a period of at least two years, manufactured asphalt cement or refined tar in a thoroughly equipped plant, and that asphalt cement or refined tar manufactured of bituminous material obtained from a similar source to that which he proposes to use shall have been in continuous and successful use in bituminous pavements constructed by the mixing method or in bituminous macadam pavements for a period of at least two years previous to the date of the letting in which his proposal was submitted.

44. *Asphalt Cement "A" Optional With Asphalt Cements "B," "C," "D" and Refined Tars "E" and "F."*

(I) Asphalt Cement "A" shall be homogeneous, free from water and shall not foam when heated to 177° C. (350° F.).

(II) It shall show a flash point of not less than 205° C. (400° F.) when tested in the New York State Board of Health Closed Oil Tester.

(III) Its specific gravity, at a temperature of 25° C. (77° F.) shall be not less than 0.960 nor more than 1.000.

(IV) When tested with a standard No. 2 needle by means of a standard penetrometer, it shall show penetrations within the following limits for the conditions stated, the penetrations being expressed in hundredths of a centimeter, 100 gram load, 5 seconds, at 25° C. (77° F.), from 100 to 120; 200 gram load, 1 minute, at 4° C. (39° F.), not less than 50.

(V) Its melting point as determined by the cube method shall be not less than 60° C. (140° F.).

(VI) When 50 grams of the material is maintained at a uniform temperature of 163° C. (325° F.) for 5 hours in an open cylindrical tin dish 5½ centimeters (about 2¼ inches) in diameter, with vertical sides measuring approximately 3½ centimeters (about 1½ inches) in depth, the loss in weight

shall not exceed 2.0 per cent of the original weight of the sample.

The penetration of the residue, when tested as described in Clause (IV) with a standard No. 2 needle under a load of 100 grams, for 5 seconds at 25° C. (77° F.) shall be not less than one-half the penetration of the original material tested under the same condition.

(VII) Its bitumen as determined by its solubility in chemically pure carbon disulphide at room temperature, shall be not less than 99.5 per cent.

(VIII) It shall be soluble in chemically pure carbon tetrachloride at room temperature, to the extent of not less than 99.5 per cent. of its bitumen as determined by Clause (VII).

(IX), It shall be soluble in 86° to 88° Baume paraffin naphtha, of which at least 85.0 per cent distills between 35° and 65° C. (95° and 149° F.), to the extent of not less than 75.0 per cent. nor more than 85.0 per cent of its bitumen as determined by Clause (VII.)

(X) It shall yield not less than 8.0 per cent nor more than 12.0 per cent of fixed carbon.

45. *Asphalt Cement "B" Optional With Asphalt Cements "A," "C," "D," and Refined Tars "E" and "F."*

(I) Asphalt cement "B" shall be homogeneous, free from water and shall not foam when heated to 177° C. (350° F.).

(II) It shall show a flash point of not less than 205° C. (400° F.) when tested in the New York State Board of Health Closed Oil Tester.

(III) Its specific gravity, at a temperature of 25° C. (77° F.) shall be not less than 1.000 nor more than 1.030.

(IV) When tested with a standard No. 2 needle by means of a standard penetrometer, it shall show penetrations within the following limits for the conditions stated, the penetrations being expressed in hundredths of a centimeter, 100 gram load, 5 seconds, at 25° C. (77° F.), from 90 to 110; 200 gram load, 1 minute, at 4° C. (39° F.), not less than 15.

(V) Its melting point as determined by the cube method shall be not less than 30° C. (86° F.).

(VI) When 50 grams of the material is maintained at a uniform temperature of 163° C. (325° F.) for 5 hours in an open cylindrical tin dish 5½ centimeters (about 2¼ inches) in diameter, with vertical sides measuring approximately 3½ centimeters (about 1½ inches) in depth, the loss in weight shall not exceed 2.0 per cent. of the original weight of the sample.

The penetration of the residue, when tested as described in Clause (IV) with a standard No. 2 needle under a load of 100 grams, for 5 seconds at 25° C. (77° F.) shall be not less than one-half the penetration of the original material tested under the same conditions.

(VII) Its bitumen, as determined by its solubility in chemically pure carbon disulphide at room temperature, shall be not less than 99.5 per cent.

(VIII) It shall be soluble in chemically pure carbon tetrachloride at room temperature, to the extent of not less than 99.5 per cent of its bitumen as determined by Clause (VII).

(IX) It shall be soluble in 86° to 88° Baume paraffin naphtha, of which at least 85.0 per cent. distills between 35° and 65° C. (95° and 149° F.), to the extent of not less than 75.0 per cent. nor more than 85.0 per cent. of its bitumen as determined by Clause (VII).

(X) It shall yield not less than 9.0 per cent. nor more than 13.0 per cent. of fixed carbon.

46. *Asphalt Cement "C" Optional With Asphalt Cements "A," "B," "D," and Refined Tars "E" and "F."*

(I) Asphalt cement "C" shall be homogeneous, free from water and shall not foam when heated to 177° C. (350° F.).

(II) It shall show a flash point of not less than 205° C. (400° F.) when tested in the New York State Board of Health Closed Oil Tester.

(III) Its specific gravity, at a temperature of 25° C. (77° F.) shall be not less than 1.025 nor more than 1.045.

(IV) When tested with a standard No. 2 needle by means of a standard penetrometer, it shall show penetrations within the following limits for the conditions stated, the penetrations being expressed in hundredths of a centimeter: 100 gram load, 5 seconds, at 25° C. (77° F.), from 110 to 130; 200 gram load, 1 minute, at 4° C. (39° F.) not less than 30.

(V) Its melting point as determined by the cube method shall be not less than 40° C. (104° F.).

(VI) When 50 grams of the material is maintained at a uniform temperature of 163° C. (325° F.) for 5 hours in an open cylindrical tin dish 5½ centimeters (about 2¼ inches) in diameter, with vertical sides measuring approximately 3½ centimeters (about 1½ inches) in depth, the loss in weight shall not exceed 2.0 per cent. of the original weight of the sample.

The penetration of the residue, when tested as described in Clause (IV) with a standard No. 2 needle under a load of 100 grams for 5 seconds at 25° C. (77° F.) shall be not less than one-half the penetration of the original material tested under the same conditions.

(VII) Its bitumen, as determined by its solubility in chemically pure carbon disulphide at room temperature, shall be not less than 99.5 per cent.

(VIII) It shall be soluble in chemically pure carbon tetrachloride at room temperature, to the extent of not less than 99.5 per cent of its bitumen as determined by Clause (VII).

(IX) It shall be soluble in 86° to 88° Baume paraffin naphtha, of which at least 85.0 per cent distills between 35° and 65° C. (95° and 149° F.) to the extent of not less than 70.0 per cent. nor more than 80.0 per cent of its bitumen as determined by Clause (VII).

(X) It shall yield not less than 12.0 per cent. nor more than 17.0 per cent. of fixed carbon.

47. *Asphalt Cement "D" Optional With Asphalt Cements "A," "B," "C," and Refined Tars "E" and "F."*

(I) Asphalt cement "D" shall be homogeneous, free from water and shall not foam when heated to 177° C. (350° F.).

(II) It shall show a flash point of not less than 163° C. (325° F.) when tested in the New York State Board of Health Closed Oil Tester.

(III) Its specific gravity, at a temperature of 25° C. (77° F.) shall be not less than 1.035 nor more than 1.060.

(IV) When tested with a standard No. 2 needle by means of a standard penetrometer, it shall show penetrations within the following limits for the conditions stated, the penetrations being expressed in hundredths of a centimeter: 100 gram load, 5 seconds, at 25° C. (77° F.), from 130 to 160; 200 gram load, 1 minute at 4° C. (39° F.), not less than 30.

(V) When tested by means of the New York Testing Laboratory Float Apparatus, the float shall not sink in water maintained at 66° C. (150° F.) in less than 120 seconds nor more than 180 seconds.

(VI) When 50 grams of the material is maintained at a uniform temperature of 163° C. (325° F.) for 5 hours in an open cylindrical tin dish 5½ centimeters (about 2¼ inches) in diameter, with vertical sides measuring approximately 3½ centimeters (about 1½ inches) in depth, the loss in weight shall not exceed 3.0 per cent of the original weight of the sample.

The penetration of the residue, when tested as described in Clause (IV) with a standard No. 2 needle under a load of 100 grams, for 5 seconds at 25° C. (77° F.) shall be not less than one-half the penetration of the original material tested under the same conditions.

(VII) Its bitumen as determined by its solubility in chemically pure carbon disulphide at room temperature, shall be not less than 94.0 per cent nor more than 98.0 per cent.

(VIII) It shall be soluble in chemically pure carbon tetrachloride at room temperature, to the extent of not less than 98.5 per cent. of its bitumen as determined by Clause (VII).

(IX) It shall be soluble in 86° to 88° Baume paraffin naphtha, of which at least 85.0 per cent. distills between 35° and 65° C. (95° and 149° F.) to the extent of not less than 75.0

per cent. nor more than 85.0 per cent. of its bitumen as determined by Clause (VII).

(X) It shall yield not less than 11.0 per cent. nor more than 14.0 per cent. of fixed carbon.

(XI) Upon ignition it shall yield not less than 1.0 per cent. nor more than 3.0 per cent. of ash.

48. *Refined Tar "E" Optional With Asphalt Cements "A," B," "C," "D," and Refined Tar "F."*

(I) Refined tar "E" shall be homogeneous, free from water, and shall not foam when heated to 121° C. (250° F.).

(II) Its specific gravity at a temperature of 25° C. (77° F.) shall be not less than 1.150 nor more than 1.200.

(III) When tested by means of the New York Testing Laboratory Float Apparatus, the float shall not sink in water maintained at 50° C. (122° F.) in less than 120 nor more than 150 seconds.

(IV) Its bitumen as determined by its solubility in chemically pure carbon disulphide at room temperature, shall be not less than 95.0 per cent., and it shall show not more than 0.2 per cent. ash upon ignition of the material insoluble in carbon disulphide.

(V) When distilled according to the tentative method recommended by Committee D-4 of the American Society for Testing Materials in 1911, it shall yield not more than 0.5 per cent. distillate at a temperature lower than 170° C. (338° F.); not more than 12.0 per cent shall distill below 270° C. (518° F.), and not more than 25.0 per cent. shall distill below 300° C. (572° F.)

(VI) The total distillate from the test made in accordance with Clause (V) shall have a specific gravity at a temperature of 25° C. (77° F.) of not less than 0.980 nor more than 1.020.

(VII) The melting point, as determined in water by the cube method, of the pitch residue remaining after distillation to 300° C. (572° F.) in accordance with the test described in Clause (V), shall be not more than 75° C. (167° F.).

49. *Refined Tar "F" Optional With Asphalt Cements "A," "B," "C," "D," and Refined Tar "E."*

(I) Refined tar "F" shall be homogeneous, free from water, and shall not foam when heated to 121° C. (250° F.)

(II) Its specific gravity at a temperature of 25° C. (77° F.) shall be not less than 1.180 nor more than 1.300.

(III) When tested by means of the New York Testing Laboratory Float Apparatus, the float shall not sink in water maintained at 50° C. (122° F.) in less than 150 nor more than 180 seconds.

(IV) Its bitumen as determined by its solubility in chemically pure carbon disulphide at room temperature, shall be not less than 80.0 per cent. nor more than 95.0 per cent., and it shall show not more than 0.2 per cent. ash upon ignition of the material insoluble in carbon disulphide.

(V) When distilled according to the tentative method recommended by Committee D-4 of the American Society for Testing Materials in 1911, it shall yield not more than 0.5 per cent. distillate at a temperature lower than 170° C. (338° F.); not more than 10.0 per cent. shall distill below 270° C. (518° F.), and not more than 20.0 per cent. shall distill below 300° C. (572° F.).

(VI) The total distillate from the test made in accordance with Clause (V) shall have a specific gravity at a temperature of 25° C. (77° F.) of not less than 1.020.

(VII) The melting point, as determined in water by the cube method, of the pitch residue remaining after distillation to 300° C. (572° F.) in accordance with the test described in Clause (V), shall be not more than 75° C. (167° F.).

50. *Delivery*—The asphalt cement or refined tar shall be delivered in suitable containers, far enough in advance of its use in the work to permit the necessary tests to be made. Each container shall be plainly labeled with the trade name of the asphalt cement or refined tar, name of manufacture, gross weight and net weight. Each shipment and each carload shall be kept separate.

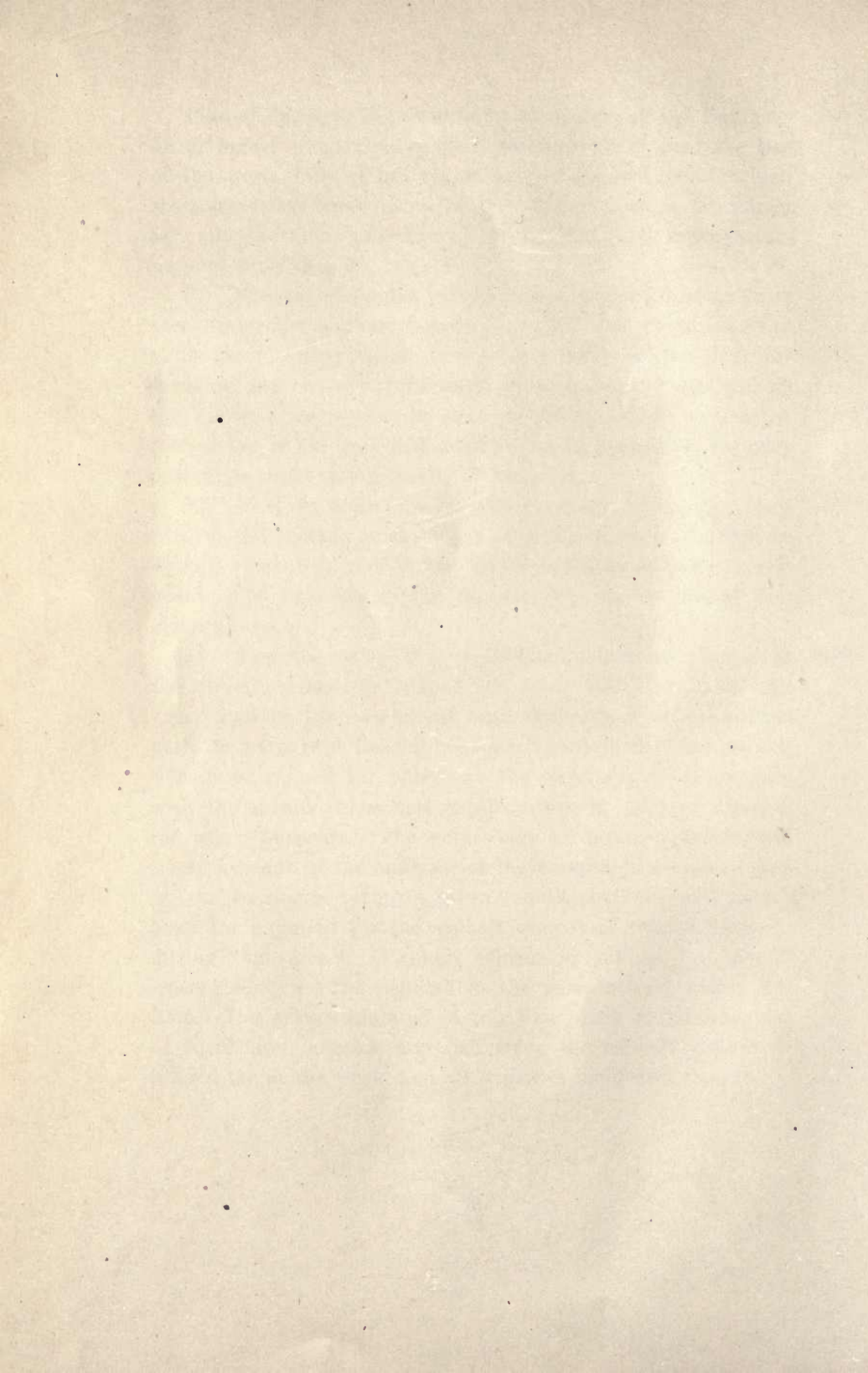
Bills of Lading—The Contractor shall furnish the Engineer on or before the arrival of each shipment at or near the site of the work, bills of lading, or correct copies thereof, which shall state the trade name of the asphalt cement or refined tar, and the name and address of the Company manufacturing and supplying it.

51. *Samples*—Samples will be taken by the Engineer from each carload of asphalt cement or refined tar when delivered at the work, unless satisfactory arrangements can be made for sampling before shipment. Such samples shall be analyzed by the Engineer to assure the delivery of an asphalt cement or refined tar of the specified quality and to determine, for purpose of payment, the quantity of bitumen.

52. *Work Included*—Under this item the Contractor shall furnish and deliver on the work at such points as directed an asphalt cement or refined tar which conforms with the specifications of any one of the asphalt cements or refined tars given above.

53. *Measurement and Payment*—The quantity of bitumen in the asphalt cement or refined tar, to be paid for under this item, shall be the number of tons, determined in accordance with the paragraph headed "*Samples*," contained in the asphalt cement or refined tar placed in the pavement in accordance with the specifications and requirements, or used as directed for other purposes. The percentage of bitumen determined by an average of the analyses of the acceptable samples taken by the Engineer during a given month shall be used as the basis for payment for the asphalt cement or refined tar used during that month. Asphalt cement or refined tar that is wasted shall not be included in the measurement under this item. The price stipulated in this item shall include the cost of furnishing, hauling and delivering the asphalt cement or refined tar at the work, and all expenses incidental thereto.







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